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Fire Blight on Pome Fruits . . . and Its Control

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Fire Blight on Pome Fruits and Its Control

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Fire blight is the most destructive disease of the pear in New York State and is nearly as injurious to some varieties of apple as it is to pear. Few plantings of the most susceptible apple varieties still exist, but certain varieties that are grown extensively and are classed as moderately susceptible may be severely damaged by the disease. Quinces, too, are severely damaged. Certain ornamental plants that also may be damaged are included in the list on page 6. The disease may be encountered on various species in the wild—both native and others that have escaped from cultivation. Sometimes these should be taken into account in a control program.

Fire blight is caused by a bacterium[1] which, once infection has developed, may move long distances within the living tissue and kill twigs, branches, or even entire trees (figure 1). In fact, a tree may be destroyed by a single infection in one season.

Qualified investigators have given the control of fire blight much attention and the necessary measures have been carefully worked out for grower application, but the procedure is somewhat complex and may need to be modified or the emphasis may need to be shifted according to circumstances in individual orchards. For this reason any new or better measures to make the job simpler are of interest to the grower. Several recent developments have stimulated a new interest in the problem and should make it possible to improve the vigor of pear trees without serious damage from this disease.

A study now under way in New York indicates that pears on well-drained soils are damaged less by fire blight than are those on the comparatively wet soil on which many existing orchards were planted. This fact should aid in the selection of sites for new orchards, and indi-

Authors' acknowledgements. Dr. L. M. Massey, Dr. G. C. Kent, and Dr. A. B. Burrell read the manuscript and made many valuable suggestions. Dr. D. S. Welch, who also read the manuscript, prepared the list of susceptible species on page 6.

[1] *Erwinia amylovora* (Burr.) Winsl. et al.

cates that any measure to improve drainage in existing orchards should help. Also, a part of the nitrogen needed by the pear tree may be added by foliage spray applications after there is time for blossom-blight infections to develop. It may be helpful to vary the amount of nitrogen applied in any season based on the severity of infection.

One of the antibiotics, used as a blossom spray, has controlled blossom infections substantially better than have the copper materials used in the past.

With the anticipated expansion in pear plantings and improved tree vigor, there may be more need for a way to prevent extensive damage by the infections that do escape protective measures, because no spray treatment is likely to prevent all infections. A paint that is capable of stopping development of new cankers when carefully applied has been available but has been used comparatively little.

These facts are the basis for a renewed interest in the control of fire blight. This bulletin, therefore, explains the application of the new control measures and their relation to those already in practice. Investigations are still in progress, and any additional information will be made available as soon as it is obtained.

Species and Varieties Affected

Fire blight is limited in nature to plants in the rose family. The only ones within that family seriously affected are included in the pome-fruit section. Many ornamental species may be affected to varying degrees, and any member of the genera listed on page 6 should be watched for appearance of the disease. In the list, all genera of the rose family shown to contain susceptible species are included whether or not the disease has been observed on them in nature. Certain of the species are native to New York State or have escaped and become established in the wild. These are starred in the list; some genera indicated as native include also naturalized species. Most susceptible species may be found in neglected sites where they have been planted and abandoned. The pathogen is, however, likely to over-winter on only a few species in addition to pear, apple, and quince. These are discussed under control.

Unfortunately, in New York State no pear that is desirable otherwise is resistant to fire blight. The most prized variety for canning, the Bartlett, is very susceptible. Of the others commonly grown in New York, Beurre Bosc, Gorham, and Clapp Favorite are perhaps more susceptible than Bartlett. Seckel, Kieffer, and Anjou are somewhat less susceptible.

The most susceptible varieties of apple are rarely found in New York orchards. Alexander belongs to this group and is occasionally found. Somewhat less but still highly susceptible and grown to some extent are Wagener and Tompkins King.

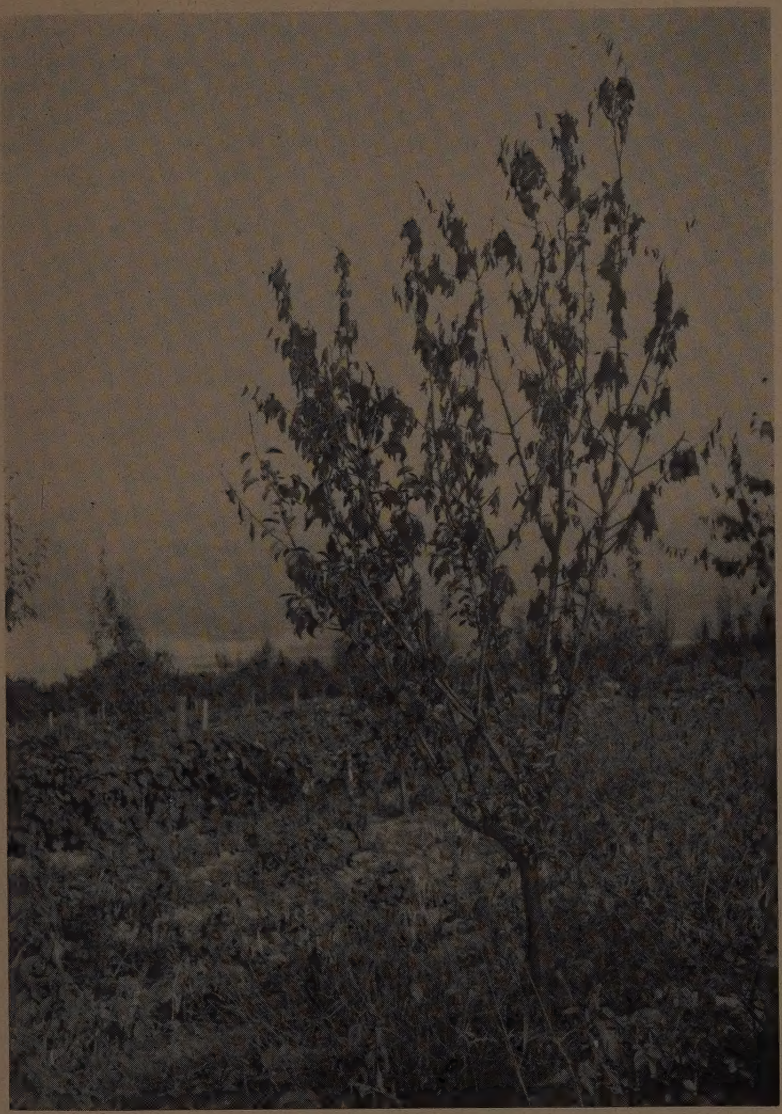

Figure 1. Young pear tree severely affected by fire blight

Rosaeceous Genera Susceptible to Fire Blight and Hardy in New York

* Amelanchier	Shad Bush, Juneberry
* Aronia	Chokeberry
Aruncus	Goats Beard
Chaenomeles	Flowering Quince
Cotoneaster	
* Crataegus	Hawthorn, Thorn Apple
Cydonia	Quince
Dryas	Mountain Avens
Exochorda	Pearl Bush
* Fragaria	Strawberry
* Geum	Avens
Holodiscus	Rock Spiraea
Kerriá	
* Mespilus	Medlar
Photinia	
* Physocarpus	Ninebark
* Potentilla	Cinquefoil
Prinsepia	
* Prunus	Stone Fruits
* Pyracantha	Firethorn
* Pyrus	Apple, Pear
Rhodotypos	Jetbead
* Rosa	Rose
* Rubus	Brambles
† Sorbaria	False Spiraea
* Sorbus	Mountain Ash
* Spiraea	

* = Native—may include also naturalized species.
† = Naturalized.

Perhaps next in order of decreasing susceptibility is Twenty Ounce, followed by Wealthy and Rhode Island Greening. Jonathan is reported as highly susceptible in other States, but the writers have had little opportunity to observe it in New York. Various crab-apple varieties are highly susceptible. Any apple variety may be damaged, particularly young highly vigorous trees. This is true even of McIntosh, one of the more resistant varieties and at present the most commonly grown variety in New York State.

Symptoms

Affected blossoms become blackened and shriveled. With further development of the disease, the leaves on the spur become brown to black and shriveled (figure 2). Affected leaves on pear tend to be very dark brown to black and those on apple brown to dark brown. Terminals and watersprouts, when infected from direct inoculation, usually wilt from the tip downward and the leaves and surface of the bark of the twig become brown to black. Affected leaves tend to persist, frequently remaining attached throughout the winter, and serve to call attention to cankers on the supporting branches.

As the infection progresses into the supporting branches, the bark surface if smooth becomes darker than normal. The inner affected tissues are at first watersoaked, later develop reddish streaks, and finally die and are brown in color. Usually when the bacteria invade branches or trunks with rough scaly bark, no evidence shows on the surface but the inner tissue is watersoaked, reddish, and finally brown.

A milky, sticky ooze containing the bacteria may form on any affected part (figure 3). This ooze turns brown on exposure to the air.

If a branch is girdled by blight infection, all of the part of the branch above the infection dies. The leaves on the lower parts directly invaded express symptoms, but the leaves on the ends of the branches wilt and eventually turn brown without developing the dark color characteristic of blight infection.

Cankers are formed by progressive invasion of branches from infected fruiting spurs, terminals, watersprouts, or wounds. As the

Figure 2. Blossom blight on pear

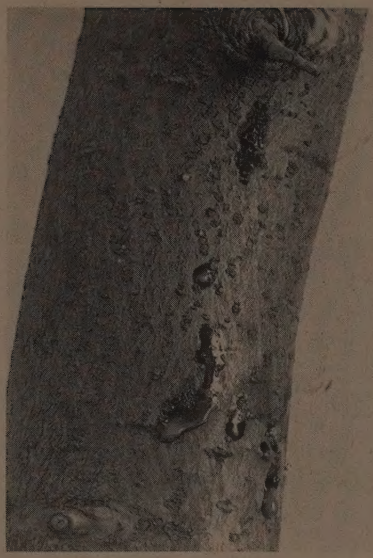

Figure 3. Bacterial ooze on surface of bark of canker on an apple branch

rate of development slows down, the margins become sunken and sometimes cracked. All bark tissue within the invaded area in such cases is dead.

Fire-blight injury is easily confused with that caused by other factors, especially low winter temperatures. Some differences between the fire-blight disease and winter injury are the following: (1) dead bark is brown in blight infections and gray mixed with white flecks in winter injury; (2) the wood is more likely to be discolored with winter injury than with blight; (3) winter injury is more likely to extend downward from cuts, be centered in crotch areas and at the base of the trunk, and be located in weaker parts of the trees; (4) the bark may become separated from the wood in winter-injured areas; and (5) there is usually an obvious infection court, such as fruit spur or watersprout, within the blight canker.

Mode of Infection

THE bacteria overwinter at the margins of lesions (cankers) developed the previous year or earlier and may survive in very small twigs but are more likely to survive in large branches. Ooze containing the bacteria is formed on the surface of the cankers and is carried into open blossoms by rainfall and probably more commonly by flies and ants that visit both the cankers and open blossoms. The bacteria multiply in the flower nectaries, providing secondary inoculum. More widespread inoculations are made by rainfall washing the bacteria from the nectaries and by bees, especially honeybees, which carry the inoculum from one blossom to another in their feeding activities.

Sucking insects, primarily aphids and leafhoppers, feeding on diseased twigs and then on healthy terminals, inoculate growing terminals and watersprouts. Aphids have been observed feeding on the ooze itself.

Mechanical wounds in the bark of branches may serve also as infection courts for inoculation by splashing rain or by insects that feed on the ooze and then visit the fresh

wounds to feed on the exposed plant sap. Wounding agents include branches rubbing against each other in the wind, hail, passage of farm equipment against the trees, and man climbing into the trees. Direct inoculations may be made by pruning during the summer if the operator cuts through a lesion and then prunes a healthy branch.

Development of Infection

Following inoculation of the blossoms, the bacteria grow in the nectar and then invade the tissue of the flower through natural openings in the nectary. Sometimes the bacteria enter through natural openings in other parts of the flower and through the stigmas.

Entry into other parts of the tree is usually through wounds, primarily those made by the sucking mouthparts of the inoculating insects. Any fresh wound may serve as an infection court whether in leaves, twigs, or in the bark of large branches. Within a few days wounds are no longer receptive to the bacteria because the healing processes develop a barrier or the wounds dry out.

Evidence indicates that in long wet periods infection may occur through natural openings in the leaves, but this is uncommon. Indeed, direct infection of leaves even through wounds probably is unimportant in New York.

Influence of Environment

Temperature and moisture

High temperature and high humidity combined favor the initiation of infection, particularly in the blossoms. High humidity is less important to the development of infections resulting from inoculations by sucking insects but, nevertheless, does favor it. Once infection is established, atmospheric humidity is less important even to blossom infections; but if the tissues are severely dried out, further development of infection is retarded.

Low temperature probably checks the progress of the infection more than dryness does. The writers have observed the stoppage of infection in blossoms without serious damage when the temperature dropped sharply at about petal-fall stage. Apparently the infections were checked and the affected blossoms dropped before the spurs became invaded.

In a study of severity of infection over a period of thirty-seven years, it was found that the more severe infections were in years when temperatures during the blossoming period were high and accompanied by at least traces of rainfall than when temperatures were low or there was no rain. This increase in severity was apparent with maximum temperatures of 65°F. but was still greater in years when the temperature reached 70°F. or higher during the blossom period. There was no

correlation with the higher temperatures unless they were accompanied by rainfall. However, based on experiments under controlled conditions by other workers, it seems probable that actual rainfall is not necessary but rather that traces of rain are an indication of high humidity. Whenever the relative humidity is high enough to favor infection, rainfall usually is enough to be recorded by the Weather Bureau.

Warm humid weather during summer, accompanied by optimum rainfall for tree growth, favors further progress of existing infections and also the initiation of new infections in growing terminals and watersprouts. Apparently under drier conditions, the inner tissue of the tree is sufficiently dry to retard infection development even though the leaves do not wilt. Very hot weather may retard infection, particularly if rainfall is deficient, probably because of the drying effect.

Soil type and cultural conditions

In recent studies in pear orchards, strong evidence indicates that the blight problem is less on well-drained sites than under wet soil conditions. In fact, in none of the orchards studied on well-drained soil was the disease of consequence.

In the same study there was some evidence that the disease is more severe in orchards on acid soil than on soil at a more favorable pH level. A pH of 5.5 to 6.5 seems best. There were indications also that fire-blight infection is somewhat less in a well-balanced nutrient situation than where nitrogen is high and other nutrients are low. Experimental evidence indicates that under some conditions the addition of potassium will retard development of infection.

At the New Jersey Agricultural Experiment Station, the late Professor M. A. Blake long held the view that blight infection is less severe on well-drained fertile soil that may be kept at an adequate nitrogen level without the addition of large amounts of nitrogen fertilizers than on other soils.

At the Cornell University Agricultural Experiment Station, Dr. E. M. Hildebrand and Dr. A. J. Heinicke found that in the same orchard apple trees under alfalfa culture were less severely infected than were those in grass sod plus nitrogen or under cultivation. There were no measurable differences in number of infections, but the extent of invasion from each infection was reduced under alfalfa culture. The reason for this difference is not known, but under alfalfa culture the soil would normally be drier than under cultivation.

Probably the worst situation is a heavy wet soil with a grass sod cover that requires heavy applications of nitrogen each year.

Control

Because of the manner of infection and development of this disease, no single control measure is adequate. Protective measures may

reduce infection but are difficult to apply, and infections that do escape are capable of extensive damage.

All the known control measures are discussed on the following pages. In some orchards all may be necessary and feasible; in other orchards, particularly of the less susceptible varieties of apple, certain measures may not be needed.

Soil conditions and cultural practices

The most important considerations are to prevent sudden increases in nitrogen supply at any time and to prevent late growth. When tree growth is stopped early in the season, lesion development is arrested sooner than when tree growth continues late. The lesions do less direct damage and are less likely to harbor viable bacteria through the winter.

It seems clear that for new plantings of pears and highly susceptible apple varieties, the selection of a fertile well-drained site is important. Tree growth stops earlier in the season on dry than on poorly drained soils. On well-drained soils, alfalfa or other deep-rooted legumes may be used as a permanent cover crop. On the less well-drained soils, alfalfa might offer too much competition with tree growth and may be difficult to maintain. Here, then, a grass cover crop would be preferable. In either case, a mulch should be applied under the trees in moderate quantities, preferably in late fall or very early spring. While the trees are young, the mulch material may be grown in the orchard itself between the rows. As the orchard grows older it may be necessary to provide additional mulch.

Late cultivation should be avoided. Indeed, except at first to get the trees established, it would probably be best not to cultivate at all but to use a sod-mulch system of culture with either an alfalfa or a grass cover crop.

Grass or alfalfa sod should be well mowed early in the season, and then usually allowed to grow in mid-summer to check tree growth at that time. If weather conditions are drier than normal, it may be necessary to keep the sod closely mowed throughout the summer; in extreme drouth, it may be necessary to disc the soil lightly. Alfalfa mowings should always be taken away or thrown around the trees as mulch.

Heavy applications of nitrogen fertilizers should not be made. If a light ground application is made in early spring and little blight infection occurs, the nitrogen program can be supplemented with urea sprays from one to three weeks after petal-fall. In years when numerous infections occur, the urea sprays may be reduced or withheld. In this way one can prevent part of the danger of stimulation of the disease that results from over-fertilization. The amount of nitrogen applied is reduced in the years of heavier infection. Where alfalfa is grown as a cover crop or where a mulch has been well established, it may not be necessary to make ground application of nitrogen at all, but to depend

on sprays for whatever added nitrogen is needed.

Potash should be added if this element is low.

Lime should be applied if needed to maintain the soil at pH 5.5 to 6.5.

For existing orchards not on well-drained sites, presumably anything that can be done to improve drainage is helpful. Also, for existing orchards, it may be feasible to change to a legume cover crop or to a sod-mulch type of culture, or to both.

Sources of inoculum in the environment

Susceptible wild or escaped hosts near the orchard or other planting should be examined and any infections in them destroyed. They may provide a continuing source of inoculum and greatly reduce the effectiveness of the most carefully planned control program. Species that should receive particular attention in New York belong to the following genera: *Crataegus* (hawthorn), *Pyrus* (pear and apple), *Pyracantha* (firethorn), and possibly *Sorbus* (mountain ash). Crab apples are among the worst offenders.

Nearby orchards or ornamental plantings may constitute a constant threat because of the danger of strong-flying insects, such as honeybees, carrying secondary inoculum into the orchard. In this group, in addition to the plants listed in the preceding paragraph, *Cydonia* (quince) should be included. In pear orchards containing no holdover cankers, the writers have observed serious outbreaks that were the result of inoculum carried from neglected orchards at least 200 yards away. The literature cites instances of the inoculum being carried greater distances. Sometimes it is necessary to enlist the neighbors' cooperation. Often, less susceptible varieties are damaged more when they are growing near highly susceptible varieties than otherwise unless the susceptible varieties are well cared for and the disease is controlled. In some orchards severely damaged by blight, the problem has been reduced by the removal of the few trees present of a highly susceptible variety which were of little value and had been neglected for that reason.

Sources of inoculum within the orchard

Bearing in mind that inoculations start with bacteria produced in old cankers, ideally all these cankers should be destroyed. Winter is the best time for this operation; and the latter part of the winter is preferred for pears, because of the danger of low-temperature injury if cuts are made earlier. During the dormant period, cuts should be made at least 1 inch, and preferably farther, below any evidence of dead bark killed by the disease. There is no need to disinfect the cuts or pruning tools if the work is done from December 1 to March 15.

On pears, it is important to remove all old infections during the winter, including those on twigs as well as the cankers on large

branches and tree trunks. On apples, probably it is not necessary to remove infections in twigs less than ¼ inch in diameter (the size of a lead pencil).

Much benefit can be expected if canker removal is carefully done. Apparently, it is easier to prevent infection from secondary inoculations than from primary; and if the orchard is free of sources of inoculum, all inoculations to blossoms will be secondary, made by strong-flying insects such as honeybees. In years when blossom infections do not occur and all previous infections have been destroyed, there is no source of inoculum for terminal infections.

Elimination of infection courts

The elimination of infection courts is valuable in any blight-control program but is rarely done. In the few cases that have come to the attention of the writers, grower experience shows this practice to be very helpful.

Healthy fruiting spurs on the lower part of the main framework on the inside of the tree should be removed during the winter. The wounds made will not serve as infection courts because they will be healed over or dried out before inoculum is available. The removal of these spurs prevents many infections which otherwise would quickly destroy large leaders or entire trees.

In orchards where a blight-control program is being initiated, there will be watersprouts in the main framework of the trees and on the trunks and root sprouts which should be removed during the winter. These are normally taken care of during the summer, as explained in the following paragraph.

During early summer, all uninfected watersprouts in the framework of the tree not needed for new branches should be broken out. There is little danger of inoculating the wounds so made if care is exercised not to take hold of diseased twigs or other parts. This operation is best done during a dry period. Healthy root sprouts should be pulled up or dug out.

Spraying for blossom-blight prevention

Experimental evidence by various workers and experience in California indicate that spray applications should be made during the bloom period at times when both temperature and relative humidity are high. Spray applications made during cold periods (maximum below 65°F.) probably do little good regardless of stage of bloom. Our information is inadequate to provide a definite figure on percentage relative humidity. If, however, liquid is evident in the nectaries of the flowers early in the morning, the humidity is probably high enough for fire-blight infection. If the nectaries are dry, probably infections could not develop and the spray is not needed.

The standard material for blight control has been bordeaux mixture (2–6–100) but experience in the West indicates that fixed coppers are

just as good. They might be used in New York State on a trial basis.

Recently, the antibiotic streptomycin sulfate has given excellent control of blossom blight. Results with this material in New York, however, have varied in different tests from good to poor, probably because the low temperatures sometimes prevailing during bloom reduce the effectiveness of the antibiotic. Unfortunately, while low temperatures reduce blight development, they reduce the effectiveness of the antibiotic still more. Experimental evidence indicates streptomycin is more effective under high temperatures when infections are developing the most rapidly and at lower temperatures the antibiotic action is sharply reduced. In spite of reduced blight development at lower temperatures, more blight develops on sprayed blossoms under low than under high temperatures.

It is, therefore, suggested that sprays be withheld until the temperature reaches 65°F. accompanied by a forecast of high humidity or rain. If 65°F. is the highest temperature expected, bordeaux mixture or some other copper may be used. If temperatures as high as 70°F. are expected, then streptomycin should be used to get the most benefit from this highly effective but expensive material. The two materials should *not* be mixed in the same application because streptomycin is broken down by alkaline conditions.

The first spray application should be made as soon after the first blossoms open as temperature and humidity are suitable for infection or are predicted. Under severe blight conditions one or two additional applications may be needed. These should be timed primarily on the basis of weather conditions but should take into account blossom stage as well. When the blossom period is very short, the applications may be two or three days apart; but when there are short warm periods during a long bloom, applications may be as much as a week apart. Frequently an application of the antibiotic late in the bloom period may be very helpful, particularly since higher temperatures are more likely at that time.

In most tests, spray injury by streptomycin sulfate has been much less than was that caused by copper sprays and so far has seemed unimportant under most conditions. Sometimes on the very young leaves, streptomycin has caused a mild chlorosis along the veins and chlorotic spots scattered over the leaf blade. Probably streptomycin should not be used at concentrations higher than 100 parts per million, although some growers using the mist spray method have applied it at three or four times this concentration without serious injury.

Streptomycin sprays have been tested for fire-blight control only on apple and pear. They should be useful on other species, but this cannot be certain without trials. If their use on other plants is contemplated,

preliminary trials on a small scale should be made to determine effectiveness for disease control and susceptibility of the plant to spray injury.

Insect control as an aid in blight control

Since sucking insects make most of the inoculations to growing terminals and watersprouts, their numbers must be kept low. Information on this phase is less complete than for blossom inoculations, but it appears that aphids and leafhoppers are the worst culprits. Dormant applications of sprays should be thoroughly made for aphid control. A careful watch should be kept for their appearance during the summer; if any are found, appropriate steps should be taken immediately to control them. It cannot be too strongly stressed that this is very important, and that damage may be severe because of inoculations made by aphids when their numbers are too small to cause important damage from their feeding alone. In other words, control measures for aphids may be needed where blight is a problem when aphids are present but their numbers are not sufficiently great so that direct control measures would otherwise be useful.

Leafhoppers probably present a more difficult problem, because they are not so readily seen as are aphids. Large numbers may be present without that fact being realized. Perhaps where blight has been severe in the past, it would be best to make spray applications early, beginning with the petal-fall, designed against leafhoppers. Infections are most likely to occur early in the growing season.

Perhaps a reasonable program would be to spray for leafhoppers at the petal-fall stage and again about 10 days later, and at the same time to keep a careful watch for aphids, including in the spray a material effective against aphids if any are found. Later applications would depend on conditions, and should be made if any aphids or leafhoppers are found. This is particularly true if there are succulent watersprouts on the trees. As soon as the shoots stop growing and form terminal buds probably insects cannot make effective inoculations on them, but succulent actively growing watersprouts may be present all summer.

Summer cutting of infected twigs

The destruction of overwintering sources of inoculum and spraying during bloom should greatly reduce the number of infections, but a few are likely to escape. On pears and on the most susceptible apple varieties, single infections may do extensive damage during summer. Sometimes it may be advisable to attempt eradicative measures at that time in order to save trees or large branches. Usually, however, on apples it is not necessary to remove the very small infected twigs on the ends of branches.

Infected twigs on the ends of small branches may be broken or cut out. At least 12 inches of normal-appearing bark below the lowest evidence of disease must be removed. If this cannot be done without the destruction of a valuable branch, the canker paint (pages 16 to 20) may be used.

The extent of each lesion can be determined on smooth bark from the darker color of the surface of the bark. If there is any doubt, small cuts will reveal the affected inner bark tissue to be watersoaked, reddish, or brownish. Such examinations, if made, should be made with a knife reserved for the purpose, or the knife should be thoroughly disinfected after each such examination if used to cut healthy tissue.

The pruning tools used to cut out infected branches or twigs should be disinfected immediately after each cut. A satisfactory disinfectant is made up of 1 part of corrosive sublimate and 1 part of cyanide of mercury in 500 parts of water, or in a mixture of water and glycerine. The disinfectant may be swabbed on the cutting tool or the tool may be dipped into it. This material is highly poisonous and must be handled with care, particularly with respect to thoroughly washing the hands after its use. It must be stored in a safe place out of the reach of children or animals and be plainly marked. The canker paint used on bark makes a good disinfectant for tools. Both the mercury disinfectant and the canker paint are corrosive to tools. Thorough washing at the end of the day followed by drying and a coating of oil will help, but at best the tools will be corroded to some extent.

Canker paint

With the old excision method for the removal of blight infections during the summer, sometimes it was necessary to remove large branches to make sure a single small infection was entirely destroyed. When the infections were on the trunks of the trees, very large areas of the bark had to be cut away. Paints have been developed which when applied to the surface of small lesions and the living bark surrounding them effectively prevent further extension of the lesion and save large branches and entire trees (figure 4). Less work is required than for the excision method and the danger of spread of infection in pruning operations is eliminated.

Three paints have been developed, two in California and one in New York. Comparative tests were made, and the cadmium sulfate paint has been selected for use in New York State on the basis of reasonable effectiveness without serious injury to the living bark.

The paint is made up as follows:

1. Dissolve commercial grade cadmium sulfate at the rate of 1 pound of the salt in 2 pints of water. This may be done by stirring in warm water or by suspending the ground material in a cloth bag in the top of a container (preferably glass or

Figure 4. Small cankers on pear branches treated with canker paint and satisfactorily healing
Photographed three years after treatment.

earthenware) of cold water as is done with copper sulfate. The material should be ground to a white powder before attempting to dissolve it in water. Probably there will be some loss of water by evaporation during the dissolving process. Make up the volume of finished solution to equal one and one-eighth of the volume of water at the start (2¼ pints in the example given). This replaces any water lost by evaporation because the salt going into solution increases the volume of liquid by one-eighth.

2. Mix the stock solution described under paragraph 1 with other materials as follows, adding the ingredients in the order named. Shake the mixture after each ingredient is added. Proportions are by volume.

Cadmium sulfate stock solution	5 parts
Glycerine, commercial grade	2 parts
Muriatic acid, concentrated	2 parts
Denatured grain alcohol	5 parts

When the alcohol is added, a cloudiness develops; but this quickly disappears on mild shaking of the mixture. Small amounts of material may settle out after the mixture has been completed. These are impurities in the crude chemicals used and need be of no concern. The mixed paint will keep indefinitely if it is kept clean and tightly stoppered in glass bottles.

The containers should be plainly labeled and marked *poison* and appropriate safety precautions taken.

The ingredients of this paint are not all readily available and the mixture is somewhat troublesome to prepare. For those who do not wish to take the trouble to make up the paint, it is available in ready-mixed form. Your County Agricultural Agent can give you the information on the ready-mixed paint, or write to the Department of Plant Pathology, Cornell University, Ithaca, New York.

Trees on which paint may be useful

Most pear trees may need treatment. Only a few varieties of apple

are likely to be benefited by it. These include Alexander, King, and Wagener. Trees in very high vigor, or young trees in moderately high or better vigor, of such varieties as Twenty Ounce, Rhode Island Greening, and Wealthy may need it occasionally. On these varieties it will be necessary in each individual orchard to decide whether painting the infections may be worthwhile.

The canker paint described has not been tested on species other than pear and apple. Probably it would be effective on others but should first be tested on a small scale to determine whether chemical injury might be too great.

Timing and method of application

Soon after petal fall, as soon as blossom blight can be found, treatment should be started. If many fruit spurs are affected, the orchard should be patrolled at intervals of one week, or less, and any infections found treated at once.

The paint may be applied with a brush to the surface of the bark on the supporting branch at the base of any affected fruit spur or small twig (figure 5). The diseased spur should then be cut off to eliminate this source of inoculum. If the branch is already invaded, as shown by the darkening of the surface of the bark (figure 6), the paint should be applied over the entire affected area and at least 8 or 10 inches beyond the upper and lower margins. Usually, it will be necessary to paint all the way around the branch.

Drawing by Mitsu Nakayama

Figure 5. Drawing of blighted fruiting spur, showing favorable stage to apply canker paint

The bark below the spur should be painted, then the spur removed. Supporting branch in drawing approximately 1 inch in diameter, the smallest that may be safely treated with this material.

The material is not fully effective after the disease has invaded more than 2 or 3 inches into the supporting branch of the infected spur. Consequently, for treating blossom spur infections it is of doubtful value more than one month after petal fall.

Caution! *This paint should be applied only to the intact bark. Paint applied to fresh cuts causes serious injury. There is no need to cut into the affected smooth bark to determine the extent of invasion when the paint is being used. The paint itself intensifies the dark color*

of the surface of the diseased bark. The dead spurs or small twigs are removed after treatment and not before.

In order to prevent injury, the spattering of leaves and fruit should be avoided. The paint probably should not be applied to branches less than 1 inch in diameter.

If the roughened bark on old trunks and on very large branches is affected, it is well to scrape off the old loose bark before treatment. This should be done carefully to prevent mechanical injury to the living bark beneath. Unfortunately, it may sometimes be necessary to make very small nicks into the living bark to determine the approximate margin of infection. These cuts should be kept to a minimum; in fact, it often is better when rough bark is involved to treat a very large area without determining the exact margins of the diseased area.

It is necessary to make sure the bark of the treated area is thoroughly wet with the canker paint. However, excessive runoff from the painted area collects in crotches and causes injury, and should be avoided.

Figure 6. Drawing showing progress of infection into supporting branches. Right, infection through blossom spur; left, infection through watersprout

Canker paint should be applied to the affected bark surface on the supporting branches and at least 8 or 10 inches above and below the darkened bark. The spur and watersprout are removed after treatment, but the bark on the supporting branch should be left intact.

Drawing by Mitsu Nakayama

On terminal and watersprout infections

The same procedure is followed on terminal and watersprout infections as on infections through fruiting spurs (figure 6). Since infections through terminals occur later, and those through watersprouts may occur any time during the summer, treatment may be made any time in the summer provided the infection is a new one and has not invaded more than 2 or 3 inches into the supporting branch.

Other considerations

The material in canker paint is caustic, and one should take care not to get it on his hands and clothing. It is best carried in a fruit jar or in some other glass jar with a wide mouth. At the end of each half day's use, the jar should be tightly closed. Partly used paint should not be returned to the original glass con-

tainer. All cutting tools should be thoroughly washed at the end of the day to reduce corrosion by the chemical.

To facilitate later examination of the treated cankers they may be marked with ordinary outside house paint after the canker paint has been applied. A narrow line of house paint applied at the apparent margin of the canker will serve later as a reference point in determining whether the canker extended its margin after treatment.

An additional precaution that applies to any work around trees containing fire-blight infections is to avoid injury to the bark of healthy parts of the tree. Such injuries are good infection courts for the bacteria, and one might cause damage by climbing in the trees to apply the canker paint or to cut out diseased twigs. It is best to do all climbing by a ladder. If it is necessary to climb in the branches of the trees, rubber-soled shoes help prevent injuries.

The description of application of this paint sounds complicated and time consuming, but it need not be. If other measures, including the removal of healthy fruit spurs and suckers from tree trunks and main framework and spraying in bloom, are carefully followed, there should be only small numbers of infections in dangerous locations where canker treatment will be needed or useful. An operator can cover a large number of trees in a day under such conditions, he will use a very small amount of material, and he can expect to save many large branches and entire trees that would otherwise be lost.

Results to be expected

Soon after the treatment is made, drops of liquid, usually brownish, may form on the treated area. If these are not definitely sticky, probably they were caused by the paint itself and are not fire-blight ooze.

After a few weeks, depressed dead spots usually appear over the cankered area. The dead spots are unlikely to extend all the way through the bark. If they are all within the diseased area or within a few inches of it and do not appear to be extensions of the original canker margin, the canker probably was stopped. If, however, the surface of the bark beyond the original margin of the canker is darkened without being sunken and there are no small dead islands of tissue, most likely the treatment was not effective and further steps are needed. Usually, it is not worthwhile to repaint a canker that has escaped the treatment. A better practice is to wait until winter and cut out the affected branch. If the paint treatment is applied early and thoroughly, however, very few cankers escape and need further attention.

Summary of control measures

For new plantings, well-drained sites should be selected.

A type of culture designed to maintain a balanced nutrient supply

without heavy applications of a nitrogen fertilizer should be followed. The pH of the soil should be determined and lime added if the soil is acid.

In all pear and some apple orchards in which blight is a problem, it is important to remove all old infections during the winter, when there is no danger of spread by the pruning operations and the margins of cankers can be determined with certainty. In mature trees of some varieties of apple, it may not be practical to cut out infections in small twigs, but those on large branches should be removed.

The blossom sprays may be useful in any pear or apple orchard in which a blight problem exists. With the present improvement in spray practices, it may be possible to improve growth of pear trees without undue risk provided the other measures discussed are carefully followed.

On pear and the most susceptible varieties of apple, and very young and vigorous plantings of the moderately susceptible apples, the canker paint may be useful to prevent loss of branches or trees before the end of the season in which the infections occur. Infections on small twigs on these trees may be cut or broken out during the summer.

Usually, no one of these measures can be expected to provide satisfactory control. On the other hand, frequently it will not be necessary to make use of all the control measures described. The grower should consider all and tailor the program for each orchard on an individual basis.

Fire Blight Control in the Nursery

THE most important control measure for nurseries is to make sure there are no nearby sources of inoculum. If this is carefully done, little trouble is to be expected in fruit-tree nurseries or in nursery plantings of ornamental plants that do not bloom in the nursery row.

For plants, such as species of *Cotoneaster,* that commonly bloom in the nursery row, the inoculum may be carried to the open blossoms from greater distances. Sometimes these plants may need a bloom spray. This should not be necessary, however, if a reasonably large area in the neighborhood is kept free of blight infections. If bloom sprays are needed, the grower should make small scale tests before he makes extensive use of any of the materials available.

Seasonal Guide to Cultural Practices and Control Measures

In any given planting, only part of the measures may be needed. All direct control measures described and most cultural practices discussed are listed here for reference.

Dormant season

1. Apply lime where needed.

2. Apply mulch if mulch materials are hauled in, or do this in late fall or very early spring.

3. Apply nitrogen fertilizers if needed, in late winter or early spring.

4. Spray for aphid control.

5. Examine neighborhood for susceptible wild hosts and neglected trees of cultivated sorts that may be affected, and destroy any cankers present or destroy the trees.

6. Remove all previous infections in pear and quince, and all except those on small twigs in apple. Examine also valuable ornamentals.

7. Remove healthy fruiting spurs and watersprouts from the main framework of the trees. Dig out root sprouts. If the summer program has been thoroughly done, very few sprouts of either kind will be present at this time.

Spring

1. Cultivate (light discing) where needed.

2. Begin mowing if maintained in sod.

3. Re-examine trees just before bloom for any cankers that may have escaped the winter removal program.

4. Spray during bloom with the antibiotic spray or with copper materials if conditions are favorable for infection.

5. Begin control program for leafhoppers at petal-fall time.

Summer

1. Keep sod, cover crop, or weeds well mowed.

2. Apply nitrogen spray, if this practice is to be followed, from one to three weeks after petal-fall.

3. If alfalfa cover crop is used and the season is unusually dry, break up the growth lightly with a disc. This may be needed for grass sod also under severe drouth conditions.

4. Continue the spray program for control of leafhoppers and aphids.

5. Break out healthy waterspouts in the framework of the trees and pull up or dig out healthy root sprouts.

6. Begin patrol of orchard for new infections within one week of petal-fall and continue at weekly to bi-weekly intervals depending on conditions. Cut or break out infections on small twigs.

7. Along with point 6, apply canker paint to infections that have progressed too far for removal without destruction of branches or trees. These treatments should, however, be done before the cankers become large.

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